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Jostens, Incorporated
Denton, Texas

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Lynda M. Ewers, Ph.D., Matthew P. Mauer, D.O., M.P.H., and Dino Mattorano, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by DataChem Laboratories, and Ardy Grote of NIOSH's Division of Physical Science and Engineering, who provided the thermal desorption tube analyses. Vince Mortimer of DSHEFS served as a consultant on ventilation issues. Desktop publishing was performed by Juanita Nelson. Review and preparation for printing was performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Jostens and the OSHA Regional Office. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self–addressed mailing label along with your written request to:

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Health Hazard Evaluation Report 98–0117–2719
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SUMMARY

On February 17, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at the Denton, Texas, facility of Jostens, a jewelry manufacturer. The requesters expressed concern for possible health effects associated with a newly–instituted powder coating process and related finishing operations. NIOSH investigators conducted a site visit at Jostens during April 16–17, 1998, to assess epoxy powder and volatile organic compound (VOC) exposures and to interview workers regarding work practices and health concerns.

Because there are no standard analytical methods specific for epoxy powders, total particulates were used as a surrogate measure for exposure. The two individuals who performed powder coating were monitored for total particulates over two days. Their time–weighted average (TWA) exposures ranged between 0.11–0.46 milligrams per cubic meter (mg/m^3) of air. No recognized exposure limits are available for epoxy powders, but NIOSH investigators recommend that exposures be minimized because of the possible immunologic effects. Based on employee interviews, approximately 27% of the employees (3 of 11) in the powder coating areas had some symptoms (rash) consistent with epoxy powder exposure.

About 45% of the employees (5 of 11) performing finishing work on the jewelry in powder coating areas reported symptoms they associated with working with a hand lacquer finishing process. Symptoms included headaches, fatigue, nausea, vomiting, dizziness, and upper respiratory or mucous membrane irritation. Air samples were collected in areas near lacquer, solvent, and heat–curing processes for an initial qualitative screening of VOCs. Personal breathing zone (PBZ) samples were quantitatively analyzed for acetone, toluene, 2–butoxyethanol, and in one area of the plant, for methyl isobutyl ketone. All airborne concentrations were well below the NIOSH recommended exposure limits (RELs), the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs), and the American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values (TLVs®). However, due to a lack of glove use or improper glove use, workers were receiving skin exposure to solvents, especially to acetone.

Employee health symptoms reported during a site visit to a jewelry manufacturing plant owned by Jostens were consistent with epoxy powder and organic solvent exposures. Epoxy powders can cause irritation, and possibly allergic reactions in hypersensitive individuals. Exposures should be reduced to the extent feasible by venting powder spray booths to the exterior of the plant, properly maintaining booth filters, and providing personal protective equipment. Skin exposures to the solvents, especially acetone, should be reduced by use of impermeable gloves. Recommendations were made to improve local exhaust ventilation in the solvent–use areas.

Keywords: SIC 3911 (Jewelry, Precious Metal) epoxy powder, organic solvents, powder spray booths, local exhaust ventilation.

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INTRODUCTION

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NIOSH conducted a site visit at Jostens during April 16–17, 1998, beginning with an opening conference attended by NIOSH investigators, Jostens' management, and employee representatives. After the conference, a NIOSH medical officer interviewed workers while two NIOSH industrial hygienists performed personal breathing zone (PBZ) and area air sampling in the areas of concern. This report presents results, conclusions, and recommendations for minimizing exposures to epoxy powders and organic solvents at the plant.

BACKGROUND

Processes

During 1997, Jostens began phasing out a lacquer finishing process and initiating an epoxy powder spraying process at the Denton facility. The purpose of both processes was to highlight the three–dimensional relief of the jewelry (primarily rings) by adding color to recessed areas, but an advantage of the new process is that epoxy powder is more durable than lacquer on the metal surfaces. The time of the NIOSH site visit was one of transition at the plant because both processes were still in use.

The lacquer finishing process involved painting colored lacquers onto the metal surfaces of rings with small brushes, and then removing excess color from the elevated areas with solvent–saturated cotton pads. Formulations of the lacquers were reported to be trade secrets by Jostens' management, but the material safety data sheets (MSDSs) for these products listed 2–butoxyethanol and other glycol ethers as components. To remove excess lacquer, workers manually wiped the jewelry with a pad saturated with solvent, usually acetone. Latex finger cots or gloves were provided for personal protection against the acetone. Small teams of workers lacquered during the first shift only at several different locations within the plant, including crest, gold cell, heritage, LTM (lustrium), and infrared areas. In two of these areas, heritage and LTM, the lacquer painting and subsequent removal occurred at tables outfitted with two stationary local exhaust ventilation hoods (Pace Fume Extraction, Multi Arm–Evac II Systems). Lacquer remaining on the jewelry was cured by heating in one centralized oven, located near an area designated as the "infrared area" in this report.

Electrostatic powder spraying required workers to use a compressed air gun to spray dry epoxy powder onto an electrically charged ring surface. The exact nature of the epoxy powder was reported to be a trade secret, but the MSDSs revealed that the powder included epoxy resins. At the time of the NIOSH visit, powder spraying occurred during the first shift in only two areas: LTM and heritage. For each area, one team member sprayed the powder, although this task was rotated among the group members. Spraying occurred intermittently throughout the day while, for most of the work day, the sprayer and other members of the group continued with the lacquering processes.

Powder spraying was performed within two ventilated booths (Wagner–Reclaim™ LB–1500). Spray guns were an integral part of each booth and were charged with epoxy powder by manually scooping powder from nearby storage drums. During spraying, the worker stood immediately in front of the hood opening, aimed the spray gun with one hand and supported the ring with the other. A non–conducting cotton glove on the supporting hand prevented electrical discharge of the metal. After application of the coating, extraneous powder was removed using suction tools located on tables outside the spray booth. Curing occurred in ovens located in each area. Imperfections in highlights applied by powder spraying were corrected using the older lacquering process.

The powder spray booths were designed specifically for small production runs. They consisted of plexiglass and metal structures, and had openings of 3 feet 6 inches wide by 2 feet 8 inches high for the booth in the LTM area and 3 feet 6 inches by 3 feet 6 inches for the one in the heritage area. According to the booth manufacturer, a minimum face velocity of 100 feet per minute (fpm) must be maintained during spraying operations.[1] After passing through two sets of particulate filters, exhaust air was returned to the work area via an opening at floor level. The initial filters were rated at 99.97% efficient for removing one micron particles, and consisted of a non–woven cellulose layer and a substratum of ultra–fine nylon fiber.[1] These filters were designed to be periodically cleaned by forcing back–flowing air through them to dislodge particles. Under these conditions filters are projected to last one to two years.[1] The final filters were composed of an AFS–3 fiberglass material, which is rated at 95% efficient for removing one micron particles.[1] Both sets of filters had water–column gauges, attached to pressure switches, designed to prevent the booth from operating if the loading became too great. According to the MSDSs, epoxy powder is potentially explosive when mixed with air, and the booth manufacturer stated that they used non–sparking components.[1]

In addition to cleaning the filters with back–flowing air as directed by the booth manufacturer, Jostens' personnel had improvised a cleaning procedure, which required the first set of filters to be removed from the booth and placed into a drum. In the drum, pressurized air was applied to the outside of the filter through a perforated tube, blowing excess powder off the filters and into the drum.

METHODS

Medical

The NIOSH medical officer conducted confidential interviews with all 11 employees involved with powder coating or hand lacquer application in the gold cell, heritage, LTM, and infrared areas. One employee, in the crest area, did not wish to be interviewed. Interviewed employees were asked about their job duties and exposures, personal protective equipment (PPE) use, workplace hygiene, health symptoms or effects, non–occupational exposures, smoking history, and medical history. The Occupational Safety and Health Administration (OSHA) Log and Summary of Occupational Injuries and Illnesses, Form 200 (OSHA 200 logs), for 1996 – April 1998 were reviewed by the medical officer.

Industrial Hygiene

Organic Solvents

Qualitative Analysis

Nine thermal desorption tubes were attached via Tygon® tubing to battery–powered sampling pumps. The sampling trains were calibrated at a flow rate of 50 milliliters per minute (ml/min) and operated from 124 to 167 minutes throughout the workday. Thermal desorption tubes were prepared by the NIOSH laboratory using stainless steel tubes configured for thermal desorption in a Perkin–Elmer ATD 400 system with an internal focusing trap packed with Carbopack B/Carboxen 100 sorbents. The thermal unit was interfaced directly to an HP5890A gas chromatograph with a HP5970 mass selective detector. A 30 meter DB–1 fused silica capillary column was used for analyses. The major compounds detected during the screening were quantitatively analyzed in the personal samples.

PBZ samples were quantitatively analyzed for acetone, toluene, 2–butoxyethanol, and, in the crest area, for methyl isobutyl ketone (MIBK). Samples were collected on 100/50 milligram (mg) solid sorbent charcoal tubes connected via Tygon® tubing to battery–powered sampling pumps, calibrated to provide a volumetric airflow rate of 50 ml/min. Analysis was by gas chromatography using flame ionization detection (FID). Acetone, toluene and MIBK were analyzed in accordance with NIOSH Methods 1300 and 1501.[2] Charcoal tubes were analyzed for 2–butoxyethanol using NIOSH method 1403.[2] Exposure values listed in this report are based on periods of actual sampling.

Epoxy Powder

Direct monitoring for epoxy powder was not possible because analytical methods do not exist for this complex substance. Instead, total particulates were monitored over two days for each of the two individuals who performed powder spraying and over one day in each of the areas (LTM and heritage) near the two powder spraying booths. The assumption was that general particulate exposure is indicative of exposure to epoxy powder. Total particulate samples were obtained using battery–powered pumps calibrated at a flow rate of 2.0 liters per minute (Lpm) attached via Tygon® tubing to preweighed 37 millimeter diameter polyvinyl chloride filters. Gravimetric analyses were performed using NIOSH method 0500.[2]

Ventilation

Velocity measurements, using a TSI VelociCalc Plus thermoanemometer, were made on the two spray booths and the local ventilation hoods used for the lacquer process. For the powder spray booths, face velocity was determined in a grid pattern over the booth openings and an arithmetic average value was calculated. For the local ventilation hoods, air flow measurements were taken at a distance of 12–14 inches from the hood opening, the approximate distance to where lacquer and solvents were used by workers. Smoke tubes were used to visually check for cross drafts in front of powder spray booths and local exhaust ventilation.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre–existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[3], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[4] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[5]. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

A time–weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8– to 10–hour workday. Some substances have recommended short–term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short–term.

Organic Solvents

Exposure to organic solvents can occur through inhalation of vapors, or by skin contact or ingestion of the liquid. Inhalation of vapors is considered a primary route of exposure because many organic solvents have relatively high vapor pressures and readily evaporate. Overexposure to many organic solvents can result in central nervous system depression, headache, nausea, and possible effects on the liver, kidney, or other organs.[6,7,8] Organic solvents (e.g., acetone) may irritate eyes, mucous membranes, and upper respiratory tract, and cause defatting of the skin and dermatitis. Solvents are among the leading causes of occupational skin disease.[7] The ability to detect the presence of a solvent by the sense of smell varies widely depending on the specific substance, and individual sensitivity. Many solvents have similar toxic effects; when there are exposures to two or more substances that act upon the same organ system, the effects are considered to be additive.

Table 1 summarizes the relevant evaluation criteria, as TWA concentrations for up to 10–hour workdays, for the primary solvents detected at the Jostens' plant.

Epoxy Powder

No established occupational health exposure criterion for epoxy powders exists. In the absence of established criteria for specific agents, it is often the convention to apply a generic exposure criterion. Formerly referred to as nuisance dust, the preferred terminology for such particulates is now "particulates, not otherwise classified (p.n.o.c.)" (used by ACGIH), or "particulates, not otherwise regulated (p.n.o.r.)" (used by OSHA). The exposure limits were intended for use with airborne dusts that do not produce significant organic disease or toxic effects when exposures are kept under reasonable control.[9] However, there is ample evidence that allergic reactions can be caused by epoxy powders.[10,11] Consequently, although the p.n.o.r. criterion may be legally applicable, the p.n.o.r. designation is not a biologically appropriate exposure criterion for epoxy powders.

The International Agency for Research on Cancer (IARC) has not classified the epoxy resins as cancer–causing agents. The MSDSs for the epoxy powder formulation warns that the product contains "chemicals known by the State of California to cause cancer and birth defects and other reproductive harm," and reports that the warning is prompted by small amounts of contaminants (arsenic, cadmium, lead, hexavalent chromium) in the powder.

Ventilation

OSHA permits the face velocities into the opening (face) of a small booth containing a manually–operated air gun to be between 150 and 250 fpm, assuming crossdrafts up to 100.[12] Face velocities less than the minimum can result in loss of particles from the booth.[12] Velocities greater than the maximum can result in eddies that can carry powders into the breathing zone of a worker standing at the opening.[13]

RESULTS

Medical

Five of 11 interviewed employees performing finishing work on the jewelry in the areas of concern reported symptoms they related to working with the hand lacquer process. Symptoms included headaches (3 workers), fatigue (3 workers), nausea (3 workers), vomiting (1 worker), dizziness (1 worker), and upper respiratory or mucous membrane irritation (4 workers). These symptoms were all reported as occurring daily or more than once per week and began either immediately after or within several weeks of starting with the hand lacquer process. Symptoms were reported as beginning shortly after the start of the workday and worsening as the day progressed. They resolved upon leaving work at the end of the day and did not occur on weekends.

One employee working with the hand lacquer process reported the onset of wheezing and shortness of breath approximately nine months after starting that work. The employee was seen by a physician but was unaware of any specific diagnosis having been made. These symptoms occurred with equal frequency both at work and at home.

Six of the 11 employees reported symptoms they related to working with the powder coating process. Symptoms included rash in areas of exposed skin (3 workers), non–productive cough (2 workers), throat irritation (1 worker), and shortness–of–breath (1 worker). Several of these symptoms were reported to improve when powder coating duties were reduced or stopped. Two employees were seen by their personal physician because of their symptoms, but the employees were not aware of any specific diagnoses.

Personal Protective Equipment Usage

None of the 11 interviewed employees reported use of respiratory protection. Two of the 11 reported "always" wearing safety glasses. One employee reported a splash of acetone in the eye recently, with severe irritation. This employee was not wearing eye protection at the time. Four of 8 employees working with the powder coating process reported "never" wearing any gloves or finger cots when powder coating. Two employees reported "never" wearing finger cots or gloves when working with the hand laquer process.

OSHA 200 Logs

Review of the OSHA 200 logs for 1998 revealed one incident of eye injury involving an employee working with the hand laquer process. No respiratory or dermatologic conditions were reported; the remainder of the entries for the areas of concern consisted of musculoskeletal injuries.

Industrial Hygiene

Organic solvents

Acetone

On each of the two monitoring days, six workers involved in lacquer finishing were monitored for acetone exposure. As can be seen in Table 2, the range for TWA acetone concentrations was large, from less than 9.1 parts per million (ppm) in the LTM area to 93 ppm in the infrared area. All PBZ exposures were well below the OSHA PEL of 1000 ppm and the NIOSH REL of 250 ppm. However, many of the workers frequently dab their fingers into acetone in the process of removing excess lacquer, and dermal exposure is a component of the overall solvent exposure not measured by air monitoring techniques.

2–Butoxyethanol

Thermal desorption tube results indicated a potential for 2–butoxyethanol exposures among workers performing lacquer finishing, and analysis of PBZ samples for 2–butoxyethanol was performed. The quantitative results, presented in Table 3, show that all air concentrations were at or below 0.32 ppm. This is well below the OSHA PEL for 2–butoxyethanol of 50 ppm and the NIOSH REL of 5 ppm. Dermal exposure to 2–butoxyethanol was not quantified.

Other Potential Organic Solvent Exposures

Thermal desorption tubes revealed the potential for toluene exposures in lacquering areas. However, toluene was not detected on the charcoal tube air samples with one exception: a sample in the crest area indicated concentrations of 0.18 ppm, considerably below the OSHA PEL of 200 ppm and the NIOSH REL of 100 ppm. A potential for MIBK exposures in the crest area was revealed by the thermal tube analyses. A single PBZ sample from a worker in the crest area was analyzed for MIBK, but none was detected on this sample. The minimum detectable concentration was 0.31 milligrams per cubic meter (mg/m^3) based on a sample volume of 6.5 liters.

Epoxy Powder

Table 4 shows the results of particulate air monitoring (the epoxy powder surrogate) of two workers performing powder spraying on each of two days. The range of concentrations was from 0.11 to 0.46 mg/m^3. Two area samples, collected near the workers in the heritage and LTM areas had low concentrations of airborne particulates, 0.03 and 0.02 mg/m^3, respectively.

Ventilation

The powder spray booth in the LTM area had an average face velocity of 234 fpm, ranging from 180 to 300 fpm. The booth in the heritage area had an average face velocity of 173 fpm, ranging from 160 to 190 fpm. Smoke released in the area qualitatively confirmed that particles were being entrained into the booth.

Two smaller (5" x 18") local ventilation hoods were sitting on bench tops near employees working with lacquer or acetone in each of the heritage and LTM areas. In the heritage area, the average face velocities were 79 fpm and 130 fpm, and at about 12–14 inches from the hood face, the approximate distance to the work area, air velocity was measured between 0–10 fpm. In the LTM area, one of the local ventilation hoods was not operating because it was not plugged in, and the other had an average face velocity of 146 fpm. The capture velocity at the working distance was not noted for this location. Smoke confirmed that none of these hoods was effectively capturing contaminants generated near the workers.

DISCUSSION AND CONCLUSIONS

Health Effects

The composition of epoxy powders is complex, generally consisting of high molecular weight epoxide resins, latent curing agents, accelerators, hardeners, pigments, and other chemicals. Several of these chemicals can induce skin irritation allergic dermatitis, urticaria, irritant dermatitis, skin photosensitivity, or bronchial asthma.[10,14] Sensitization may occur to more than one compound: in a study of patients who had been diagnosed with allergy to epoxy resin compounds, skin tests revealed that 30% were sensitive to more than one of three main epoxy resin compound groups: resins, hardeners, and reactive diluents.[10] It is important to note that once a worker has become sensitized even a minimal exposure is sufficient to cause symptoms. Prevention by avoidance of contact with epoxy powders is the best course for maintaining a healthy workforce.[10,11]

The three reports of rash related to powder coating are consistent with health effects that may occur with exposure to epoxy powder. The solid powder used at Jostens contains epoxy resins of a higher molecular weight than liquid epoxy formulations used in many industries. High molecular weight is thought to reduce, but not eliminate, the epoxy's potential to become an allergen.[10,15] Epoxy resin powder of high molecular weight has been reported to cause skin sensitization (allergy), but such sensitization is rare.[16] The MSDSs for the epoxy powder used in the powder coating process at this plant specifically lists skin irritation and skin sensitization as possible health effects. Other factors affecting the development of allergic reactions include frequency of contact with the causative agents, concentration of the epoxy compound used, amount of epoxy powder inhaled, size of the contaminated skin area, and use of PPE.

During the NIOSH site visit, concerns were expressed about cancer risks associated with chemical exposures. Evidence regarding carcinogenicity of the epoxy powder, acetone, and hand lacquer agents is inconclusive. The International Agency for Research on Cancer has not classified these agents for carcinogenic effects, nor has NIOSH recognized any as potential occupational carcinogens. Any current cases of cancer in employees of this facility would not be attributable to workplace exposure to epoxy powder because of the recent introduction of the powder coating process. Generally, a latency period of 12 to 25 years from first exposure is necessary before the development of cancer.[17]

The reports of headache, fatigue, nausea, vomiting, dizziness, and upper respiratory symptoms in employees involved with the hand lacquer process are consistent with health effects that can be caused by exposure to solvents such as acetone and 2–butoxyethanol. Solvent exposure may cause upper respiratory or mucous membrane irritation, headaches, defatting and drying of the skin, and central nervous system effects.[14] The temporal relationship noted, with symptoms worsening during the work shift and improving when away from work, is consistent with a workplace exposure. Although air sampling showed acetone, toluene, MIBK, and 2–butoxyethanol at levels well below occupational exposure limits, it is possible that the reported symptoms may be related to workplace solvent exposure. Solvent exposure can occur by dermal absorption as well as inhalation. It is difficult to quantify the level of dermal absorption of solvents. However, it is likely that exposure due to dermal absorption does occur based on the lack of consistent glove use, the improper glove materials, and the amount of time spent hand lacquering each day. Studies have estimated that a 2–hour dermal exposure to acetone is equivalent to a 2–hour inhalation exposure to 50–150 ppm, and a 4–hour dermal exposure is equivalent to a 2–hour inhalation exposure to 250–500 ppm acetone.[18] Thus, when potential dermal and air exposures are combined, a total exposure which could cause the reported symptoms is possible.

Even at exposure levels below occupational limits, it is possible that employees could experience health symptoms due to individual variability in susceptibility. Exposure limits and recommendations are usually set according to the expected effects for the average worker. In a workplace population it is possible that some employees will be affected by levels of exposure that do not cause health effects for the majority of the population. Another consideration at Jostens is the exposure to several solvents in the lacquer process. With a mixed solvent exposure the effects of each solvent are at least additive and may be synergistic, which could increase the likelihood of health effects among those who are exposed.[17]

Engineering Controls

Local exhaust ventilation operating in the areas of the lacquer finishing was not adequate to reduce VOC exposures to the workers. Hood openings could not be readily adjusted to be close to the area of solvent use. At the approximate working distance, measured flow rates were inadequate to compensate for room air currents, which are usually considered to be a minimum of 50 fpm. In one case, openings were placed at opposite ends of the table, potentially neutralizing one another in the area where work was performed. Workers did not appear to be aware that local ventilation was in operation, and they sometimes used the hood openings as a storage area for tools, a practice which further reduced the effectiveness of the ventilation.

Some theoretical calculations were performed to estimate the air flow needed at the hood face to capture contaminants at 14 inches where work was performed, using the following equation:

$$\mathbf{Q = V(5X^2 + A)}$$

where Q is the required air flow in cubic feet per minute (cfm),
V is the velocity necessary to capture contaminants where they are released (fpm),

X is the distance between the hood opening and the work area where the contaminants are released (feet), and
A is the hood face area in square feet (ft^2).[19]

Capture velocities ranging from 50 to 100 fpm are required for contaminants released into relatively quiet air.[12,13] To achieve these capture velocities at the 12–14 inch working distance, the above equation indicates that flow rates at the hood opening would have to be greatly increased, to between 370 and 740 cfm from the 50 to 90 cfm observed. However, the equation also shows that the air flow at the hood opening must increase by the square of the distance between the working area and the hood opening. Moving the working area closer to the hood opening would be another, perhaps more acceptable, way of reducing solvent exposures. No matter what the flow rate, in no case should two local exhaust ventilation openings oppose one another on opposite ends of the table.

Both of the larger spray booths used during powder spraying had average face velocities within OSHA's recommended range of 150–250 fpm, a velocity sufficient to capture particles released at low velocity into moderately still air.[13] These booths recirculated exhaust air after directing it through two sets of filters, each of which was provided with gauges monitoring pressure differences and pressure switches to stop operations should overloading of either filter occur. However, a maintenance practice in use at the time could defeat this safety feature. Booth filters were being cleaned in an improvised device by applying pressurized air to their exterior, a procedure not recommended by the spray booth manufacturer.[1] The primary filters appeared to be abraded at the positions where pressurized air was applied. Compromised filters could allow release of epoxy powder into the workroom air, and pressure switches, designed to respond to a high pressure differential, would not alert workers to air easily passing through without proper filtration.

Some of the NIOSH guidelines for recirculating exhaust air were not being met with this powder spray booth system.[20] For example, contaminants and concentration levels were not being monitored in the exhaust air. The MSDSs indicated that the epoxy powder contained small but detectable quantities of carcinogenic components. If these components are detectable in the exhaust air, recirculation should not be used.

Personal Protective Equipment

Employees did not always use safety glasses when they should have. Safety glasses should always be worn when there is a potential for anything to be splashed or sprayed into the eyes. Acetone and the hand lacquer agents can cause severe irritation of the eyes, blurred vision, swelling of the conjunctiva, and possibly corneal injury.

Fifty percent of employees working with powder coating reported "never" wearing gloves or finger cots. As mentioned above, epoxy powder can cause skin irritation and allergic sensitization. Most employees working with the hand lacquer process were observed to wear finger cots. However, the finger cots used were not made of the appropriate material for solvent protection. Thus, the employees were not receiving the perceived benefit of protection from skin contact with the laquer and acetone. Additionally, two employees reported "never" wearing skin protection for this process. Acetone and the hand lacquer agents can cause defatting and drying of the skin resulting in cracks, irritation, and dermatitis. Solvents can also be absorbed through the skin, contributing to the total systemic dose.

RECOMMENDATIONS

Engineering Controls

♦ Local exhaust ventilation during lacquer application was not working as designed. To minimize exposures to solvents the company should modify the hoods or provide flexible arms with flanges so they can be adjusted closer to the work areas. Exhaust air should be vented outside the plant or filtered through charcoal filters. Workers should be trained to use the ventilation devices properly.

♦ Face velocities on the powder spray booths appear adequate, but booths should be vented to the outside of the building. Filters should not be cleaned for reuse and should not be used if they show signs of wear. Move the epoxy powder storage bins closer to the hoods, thereby reducing chances for exposure during refilling of powder spray guns. Workers should not use the powder spray guns to clean the interior of the booths; they should use the high–efficiency particulate air (HEPA) vacuum cleaners provided.

Personal Protective Equipment

♦ Use safety glasses in work areas for both powder coating and hand lacquer application.

♦ Use impermeable gloves during the powder coating process. Finger cots will not offer adequate protection for this exposure. Cotton gloves may be worn over impermeable gloves to alleviate process–related problems during spray coating. Gloves must be kept clean; use of gloves contaminated on the inside surface may actually increase exposures. NOTE: To avoid any risk of the development of latex allergy and other latex–related health problems, non–latex impermeable gloves should be used when feasible. Also, latex gloves are not protective against solvent exposures. In the work areas evaluated during this HHE, there was no exposure for which latex would be the preferred glove material.

♦ Dermal exposures to acetone and 2–butoxyethanol should be minimized or eliminated. Use cotton swabs to apply acetone rather than place the acetone–saturated pads directly on the skin. Otherwise, use impermeable gloves during hand lacquer application and use of acetone. The latex finger cots now employed will not provide adequate protection from skin irritation effects and dermal absorption of solvents. Consultation with a glove manufacturer may be helpful to identify an acceptable glove in terms of permeability and flexibility.

♦ Protective gowns and sleeve protectors can reduce skin contact with the epoxy powder in areas not covered by gloves.

Hygiene

♦ Irritants and allergens that have come in contact with exposed skin should be washed off with mild soap and water as soon as possible. Residual soap should be washed off the skin surface. Special attention should be directed toward selecting soaps and skin cleansers since they themselves can serve as irritants. Use of harsh and abrasive cleansers should be minimized. Certain components of soaps or moisturizers (e.g., lanolin and fragrances) are known allergens and may cause allergic contact dermatitis in susceptible individuals.

♦ Clothing contaminated with known irritants or allergens should be removed immediately and laundered (preferably by the company) prior to re–use. This is particularly applicable to the epoxy powder in clothing from those employees not wearing protective gowns. If clothing contamination occurs frequently, protective gowns should be provided and laundered by the company.

Education

♦ Education and training for employees regarding the possible health effects of agents being used should be improved. Proper PPE should be provided and employees should be trained in its use. Employees must be made aware of the availability of MSDSs for the agents that they are working with. Training should ensure that employees know what procedures to follow if a potential occupational illness, injury, or health effect occurs.

Evaluation, Reporting, and Surveillance

♦ Workers should be encouraged to report all possible work–related health problems. These problems should be investigated on an individual basis by the company and consulting health care providers. Because the causes of such health effects and diseases may be difficult to assess, each person with possible work–related health problems needs to be fully evaluated by a physician, preferably one with expertise in occupational medicine. A complete evaluation would include a full medical and occupational history, a medical exam, a review of exposures, possible diagnostic tests (such as skin patch tests to detect causes of allergic contact dermatitis), and complete follow–up to note the progress of the individual. Individuals with definite or possible occupational health effects should be protected from exposures to presumed causes or exacerbators of the disease. In some cases, workers may have to be reassigned to areas where exposure is minimized or nonexistent. Employees reassigned for work–related medical reasons should not lose seniority, wages, or other benefits to which they would be entitled had they not been reassigned.

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Table 1
HETA #98–0117
Jostens, Incorporated
Evaluation Criteria

Compound	NIOSH (10–hr TWA)	OSHA (8–hr TWA)	ACGIH (8–hr TWA)
Acetone	250	1000	500
Toluene	100	200	50
2–butoxyethanol	5 (skin)	none	25 (skin)

Notes: Time–weighted average (TWA) concentration in ppm for up to 10 hours/day in ppm.
Skin notation indicates that this compound is readily absorbed through the skin.

Table 2
HETA #98-0117
Jostens, Incorporated
TWA acetone exposures among workers performing lacquer finishing

Date Sampled	Area	Acetone TWA (ppm)	Sampling Time (minutes)
4/16/98	Heritage	49	549
	LTM	74	442
	Gold	63	546
		23	541
	Crest	23	127
	Infrared	93	574
4/17/98	Heritage	35	138
		87	133
	LTM	9.1	147
	Gold	38	146
	Crest	24	133

Table 3
HETA #98-0117
Jostens, Incorporated
2–butoxyethanol exposures among workers performing lacquer finishing

Date Sampled	Area	2–butoxyethanol TWA (ppm)	Sampling Time (minutes)
4/16/98	Heritage	0.04	549
	LTM	0.09	569
	Gold	0.13	270
		0.05	579
	Crest	0.06	359
	Infrared	0.11	514
4/17/98	Heritage	0.05	363
	LTM	0.17	363
	Gold	0.16	363
	Infrared	0.32	150

Table 4
HETA #98-0117
Jostens, Incorporated
Airborne particulate exposures of workers performing epoxy powder spraying

Date Sampled	Area	Total particulates (mg/m^3)	Sampling Time (minutes)
4/16/98	Heritage	0.20	549
	LTM	0.46	567
4/17/98	Heritage	0.11	521
	LTM	0.19	302

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4676)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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